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Multivariate Analysis of Meteorological Parameters in São Paulo City

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ABSTRACT
Formation and decomposition of NOx and ozone are closely linked to several respiratory and environmental problems, making the study of these compounds of great importance.With the number of automobiles growing steadily, beyond the rampant industrialization in certain developing countries, it has endangered a serious problem, especially in industrialized urban centers, which is air pollution, also generating deaths due to certain components toxicity.In this work, Statistica and Excel softwarehave been used for a more concise analysis of results and relations of parameters. With statistics, it was able to obtain analysis from multi-variational statistic, coupling parameters and elucidating relations among them. Using Excel, we could obtain a better evaluation of variation of compounds in relation to time, so we can then make the means of each month to divide the study among the year seasons.This paper's goal is to analyze and verify relationship between ozone and NOx, in besides observing which meteorological parameters are closely related to the higher or lower formation of these compounds, based on meteorological data collection of NOx and ozone compounds, besides several data obtained at CETESB, USP station, São Paulo.According to obtained data, some points were selected for a more precise analysis of ozone concentrations. Data have been obtained during 24 hours, and observing a significant concentration pattern afterward, it was verified that this interval is of 6h up to 18h. Thus, data were selected in those time periods over a year. With all data obtained, analyzed and generated in graphs and comparisons, it was possible to observe the direct connection between NOx and ozone, with variation according to the year seasons, being more specific according to changes in temperature, pressure, rainfall, and even with quantity of passing cars.

Keywords: Climatic variability, multivariate analysis, NOx, Ozone.

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I. INTRODUCTION

People constantly face with news related to natural disasters or problems in the environment, whether by pollution or disease and even extinctions of living beings.These increasingly recurring problems may be related to certain types of compounds in environment that, in reaction with other compounds, become harmful to health.

Air pollution has long been a major problem in industrialized urban centers, with the increasing presence of automobiles [1,13].Episodes of excessive pollution caused an increase in the number of deaths in several cities around the world, according to Pinto, [2,14]."In the last century, people have seen the heyday of man's intervention on the planet, with the appearance of combustion engines, with the burning of fossil fuels, with the emergence of the steel and chemical industries.These processes were not accompanied by analyzes that could assess their impact on the environment, the toxicity of waste produced or the likely health damage".Unfortunately, it realized that one of the most fundamental elements that has been attacked by man is air. Since the same would be indispensable for the life not only human, but also of several living beings. According to Braga [3,15], it probably received no greater attention because it was abundant, invisible, and odorless.Therefore, in recent times, people have come across disastrous results of this disordered process.

Ozone, an odorless, colorless and widely encountered compound that in a certain amount is responsible for aggravating respiratory problems, is becoming more frequent in its concentration in the metropolitan area of São Paulo (CETESB) [4].According to the report itself, the effects of ozone healthcare: "cough, irritation in throat, eyes and nose. In extreme cases, according to physicians, pollution can aggravate cardiovascular problems and lead to heart attack. ".

NOx (nitrogen oxides) are important pollutants, hence people see increasingly numerous and popular articles made about these compounds, denoting not only concern with global changes but also with regard to the effects of environment generated by their concentration on large amount [5,16].

Cars, for the most part, are responsible for forming NOx compounds. According to Dümes [6], recent research has pointed out that 68% of air pollutants come from cars.Moreover, when it happens in urban areas, this number ends up increasing exponentially, reaching around 90%. In a large urban city, there is a high formation of NOx and, as seen previously, being a great polluter, ends up consisting of mortality of living beings, both human and animal.

According to Saldiva [7], there is a worrying relationship between air pollution and mortality rate of elderly, causing more studies related to this area to be made in order to elucidate, in a succinct way, a direct relation on which factors compose and corroborate with the production of pollutants, since they are already responsible for deaths in humans.

However, it is observed that in compounds such as NOx and Ozone, all the medium and conditions in which they are formed must be taken into account. In addition, ozone concentrations are strongly linked to weather conditions. Several factors, including some specific ones such as in coastal regions and presence of sea breezes, are also capable of affecting the concentration [8]. Therefore, it is necessary to develop a model that can combine and relate concentrations of ozone and NOx with the many variables that cause or inhibit their production to predict their concentrations more succinctly.

Atmospheric systems involve different spatial and temporal scales that contribute to the regional climatic variety of different intensities and occurrences, and in one region may be performance of several atmospheric phenomena [9]. This means that even an area that does not have very high production of certain pollutants can receive from other more polluting regions, thus transforming a more general problem than a regional one.

Climate systems are extremely complex. Until recently, they worked from simple equation systems, such as attempts to predict events, but with great errors and uncertainties, and relationships among climatic variabilities are often non-linear [10].

Using multi-variational statistical techniques, it allows elucidating data, thus exemplifying the work, since it reduces unstable indexes, making it possible to identify the most important index applied to the activity by means of explained variance for each component [11]. As for example, for an analysis that needs a place to observe a certain type of event, if it is used by means of multi-variational statistics, one can know which place among the chosen ones is more conducive to a given event.

II. METHODOLOGY

In order to do this article, several data were obtained, besides statistical studies to analyze the results. Data provided by CETESB[4,12] were used, which showed variation of rainfall index, ozone concentration and NOx and the average traffic at the research site during the two-year period, both analyzed at ambient temperature and pressure.From these data, graphs were plotted using Statistica® software (such software works with visualization and management of statistical data) and Microsoft Excel ®. In addition, Statistica® works with multivariate statistics, which couples different results showing how dependent the concentration of one element is on the other, for instance.

According to the data obtained, some points were selected for a more precise analysis of ozone concentrations. Data were obtained for 24 hours and, after observing a significant concentration pattern, it was found that this range is from 6 hours to 18 hours. Thus, data were selected in those time periods during a year, also observing the change of climatic seasons.

In order to enter the data in the software properly, we defined certain patterns and the year was divided into four stations so that the analysis obtained could be detailed. In order to observe the data correctly and in view of its large number, an average was made for each factor.

So that results are true to reality, one must study conditions of daily life. In order to discover which factors influence formation of ozone and NOx, one observes common factors of daily life, such as climatic factors and frequency of vehicles.

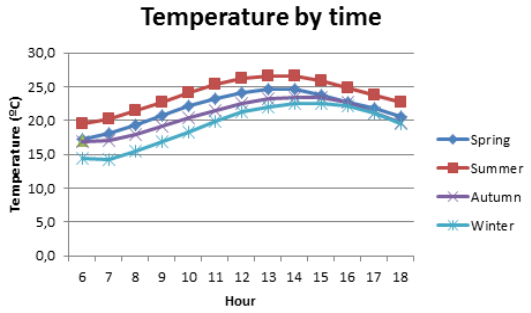

Figure 1. Based on an average among the days of each season, the average temperature for a period from 6 to 18 hours.

A second representative factor is the pluviometric index, since in the case of NOx and ozone, it may have highlighted paper in mechanism of rainfall formation and precipitation index may be presented in an interesting way in the study.

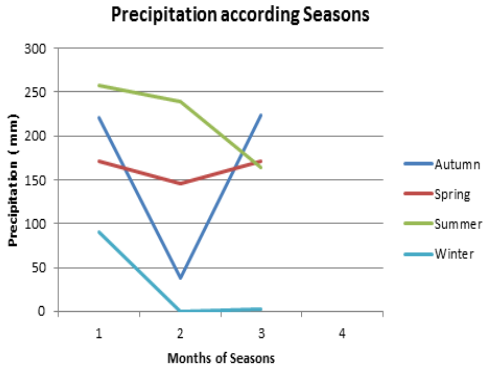

Figure 2 - Precipitation by months of each season in millimeters.

A third representative factor is the vehicles frequency, as its influence on atmospheric factors is remarkable. As 68% of the air pollutants come from cars, and this percentage of pollutants generated by cars rises, if only considered urban areas, reaching 90%.

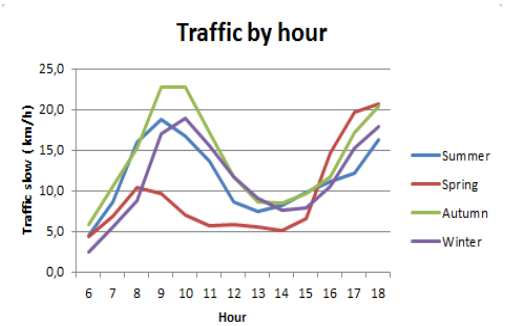

Figure 3. Based on an average among the days of each station, average frequency for the period from 6 to 18 hours, where one observes the speed in km/h and the time in hours.

With the main factors observed during each season of the year, one must enter into the part of NOx and ozone behavior in that same time period. Also with the data provided by CETESB, it was possible to obtain an average and to compare the behavior of one according to the other.

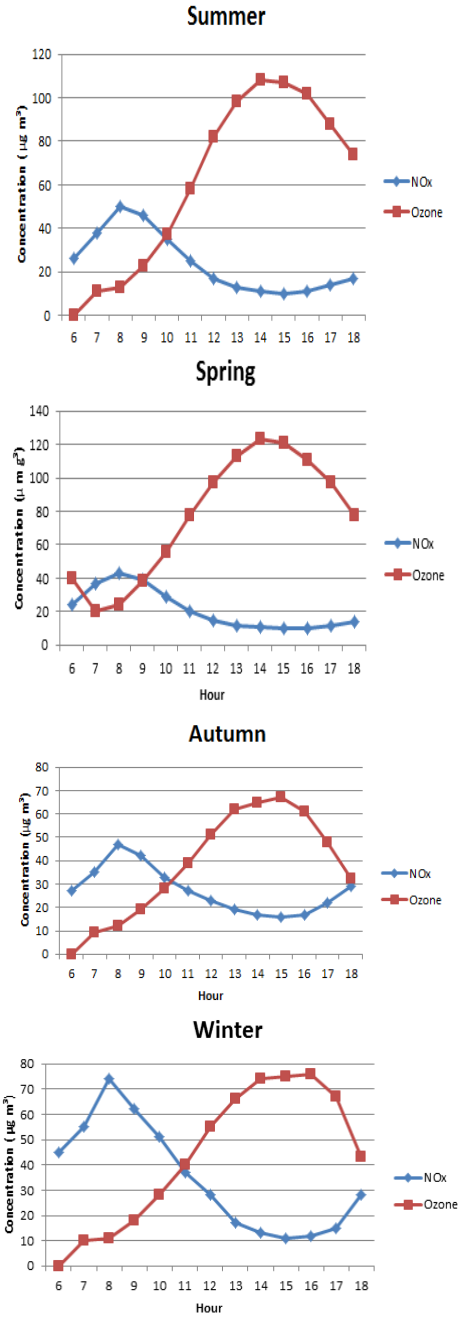

Figure 4. Set of graphs to study NOx and ozone behavior in function of their average concentration in 6 to 18 hours. The concentration is in µg/m^3 and in time in hours.

III. RESULTS AND DISCUSSIONS

After obtaining the graphs shown previously, it was possible to make a dendogram with this information. A dendrogram (dendro = tree) is a specific type of diagram or iconic representation that organizes certain factors and variables. It results from a statistical analysis of certain data, which employs a quantitative method that leads to groupings and their ascending hierarchical ordering - which in graphical terms resembles the branches of a tree that are divided successively in others.

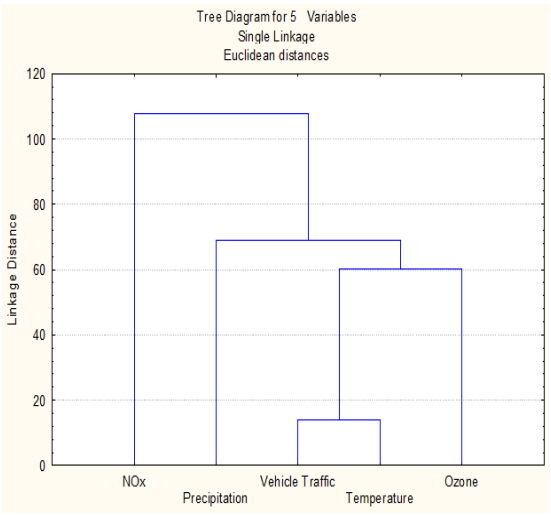

Figure 5. Dendogram showing the relationships among the factors taken into account in this article and ozone and NOx.

By means of the chart above, one observes the relationships and dependencies between the factors that were cited in the methodology and the NOx and ozone. In horizontal it is seen the concentration of NOx, precipitation index of rain, traffic, temperature and ozone concentration, respectively. In vertical it is displayed connection distance, that is, the smaller the number, the greater the relation between the factors.

For example, at first sight, it is observed that the traffic soon joins with temperature, having a higher degree of relation. This is due to the burning of fossil fuels produces gases that contribute to the heating of temperature, aggravating the greenhouse effect.

Next, it is observed that traffic-temperature relationship meets the ozone concentration. It means that increased traffic and the consequent rise in temperature affect the amount of ozone concentration. Subsequently, this relationship is with precipitation and, finally, with NOx concentration.

With the objective of improving living conditions by reducing pollution, it is noticeable that the way to reduce the high concentrations of ozone, seen in recent times, is entering with policies of incentives for a better organization in the number of vehicles, mainly in large centers.

By implementing the rotation and encouraging the use of means of transport that do not harm the environment, significant results can be obtained for improvements in society. Not only is it ozone, one can imagine the graph above as a tree and at the base of this tree is the traffic-temperature relationship.

Since this relation is the basis, one observes the dependence of other factors in relation to this one. Of course, different degrees of the relationship between ozone concentrations and NOx (ozone is more closely connected compared to NOx), but looking for solutions in the base, one can get positive results if propagating in its entire flow.

IV. CONCLUSIONS

The relationship between the variables, such as ozone and NOx compounds, can be verified by means of dendogram.It can be concluded that the increase in vehicle traffic is directly proportional to the increase in ozone formation, but it is not the only factor that changes its concentration, as it can be observed, there is a connection between temperature and its concentration, so that when hours pass, temperature has its peak between 12.00 pm and 2.00 pm and, in the same interval, it is observed a great ozone formation, therefore, temperature is a preponderant factor for its formation, besides quantity of vehicles.

Another factor observed was the pluviometric index, whose high level is responsible for the increase in NOx concentration because, according to the nitrogen cycle, it is contained in the air near the soil, nevertheless with rain, it rises to layers closer to ozone, allowing Nitrogen atoms to bind to the free oxygen atoms, leading to NOx formation.

It was also demonstrated that the connection rate is low between NOx and ozone, denoting they are inversely connected.

Parameters such as direction and speed of the wind were discarded because they have very large connection levels among the components, so there is no direct or inverse link among them.

It is worth noting that Resolution No. 3 of CONAMA states that the concentration of ozone during the day should be less than 80.16 ppb and this value can only be exceeded once a year. However, observing the charts of seasons, it is noted that this limit is exceeded not only once, but many, which makes the situation serious. From this analysis and for the purpose of improving living conditions, a better organization in the number of

vehicles and/or how they affect the environment is necessary to normalize the concentration levels of ozone and, because they are linked, the NOx concentration.

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REFERENCES

[1]. Amaral, M. DjaniraandPiubeli, F. Amaral 2003, "A Poluição atmosférica interferindo na qualidade de vida da sociedade".

[2]. Pinto, Miguel F. T. Dezembro 2008, "Modelação do transporte e dispersão atmosférica de poluentes produzidos por uma refinaria: Estudo de caso".

[3]. Braga, Alfesio; Böhm, György M.; Pereira, Luiz A. A. andSaldiva, Paulo. 2001 "Poluição atmosférica e saúde humana".

[4]. CETESB (2010-2011) - Relatório de Qualidade do Ar no Estado de São Paulo, 2008, Secretaria do Meio Ambiente, Série Relatórios – ISSN 0103-4103, São Paulo.

[5]. Williams, E. J., G. L. Hutchinson, and F. C. Fehsenfeld. 1992, "NOx and N2O Emissions from Soil, Global Biogeochem. Cycles, 6(4), 351–388, doi: 10.1029/92GB02124".

[6]. Dumes, A., "Transcrição de Poluição atmosférica gerada pelos automóveis".

[7]. Saldiva, P. H. N. ; III, C. A. P. ; Schwartz, J. ; Dockery, D. W Lichtenfels, Ana Júlia F C ; Salge, J. M. ; Barone, I. A. ; Böhm, György M . 1994 "Air Pollution and Mortality in Elderly People: A Time-Series Study in Sao Paulo, Brazil. The Tenth Health Effects Institute Annual Conference Program Abstracts for Poster Sessions. p. 43-43".

[8]. A.S. Luna, M.L.L. Paredes, G.C.G. de Oliveira, S.M. Correa, 2014 "Prediction of ozone concentration in tropospheric levels using artificial neural networks and support vector machine at Rio de Janeiro, Brazil".

[9]. Reboita, Michelle; Krusche, Nisia&Piccoli, Humberto Camargo.2006 "Climate Variability in Rio Grande, RS, Brazil: A Quantitative Analysis of Contributions due to Atmospheric Systems".

[10]. Cannon, A. J. and McKendry, I. G. 2002, "A graphical sensitivity analysis for statistical climate models: application to Indian monsoon rainfall prediction by artificial neural networks and multiple linear regression models. Int. J. Climatol., 22: 1687–1708. doi: 10.1002/joc.811".

[11]. Soares, F.r. 2011 "Use of multivariate techniques in the analysis of instability indices and lightning in the summer of 2008/2009".

[12]. Hoffmann B, Moebus S, Stang A, Beck EM, Dragano N, Mohlenkamp S et al. Residence close to high traffic and prevalence of coronary heart disease. European Heart Journal 2006; 27, 2696-702.

[13]. Diniz, M. C. S.; Correia, M. F.; Melo E. C. S.; Farias, W. R. G.; Aragão, M. R. S. 2005 "Importância Relativa de Variáveis Meteorológicas na Formação da Convecção Profunda: Uma Aplicação da Análise Fatorial de Componentes Principais."

[14]. Galichio, Wagner, 2007 "Estudo da relaçao ente ozônio e parâmetros meteorológicos na atmosfera de São Paulo".

[15]. Hirota, Marina; Nobre, Carlos; Oyama, Marcos Daisuke. Et al. 2011 "Concurrent climate impacts of tropical South America land-cover change. Atmospheric Science Letters, v. 12, p. 261-267".

[16]. MO Andreae, OC Acevedo, A Araùjo, P Artaxo, CGG Barbosa et al. 2015 " The Amazon Tall Tower Observatory (ATTO) in the remote Amazon Basin: overview of first results from ecosystem ecology, meteorology, trace gas, and aerosol measurements".

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